Renewable and Sustainable Energy Reviews 22 (2013) 198–208

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Incentives to promote solar thermal energy in Spain

M.P. Pablo-Romero*, A. Sánchez-Braza [1], M. Pérez [2]

Economic Analysis Departament, Facultad de CC. Económicas y Empresariales, University of Seville, Ramon y Cajal 1, 41018 Seville, Spain

ARTICLE INFO

Article history:
Received 2 November 2012
Received in revised form
23 January 2013
Accepted 26 January 2013
Available online 1 March 2013

Keywords:
Solar thermal energy
Tax incentives
Spain

ABSTRACT

The growth in the use of Renewable Energies in Spain has been remarkable. Among these energies is solar thermal energy. However, there are barriers which impede citizens from deciding to install the technologies that use this type of energy in their homes. Over recent years, various measures have been adopted to enhance and promote the use of solar thermal energy. These measures have been developed at all administrative levels: central, regional and local. One of the most used measures has been the adoption of legislative regulations that force the use of this type of energy in construction. Another alternative route is promotion by means of incentives, in three aspects: tax incentives, non-refundable grants and favourable lines of finance. However, the measures applied have been found to be insufficient, and alternative stimuli are needed.

Contents

1. Introduction

The residential sector is a key sector in the Spanish energy context and in the European Union 27 (EU27), due to the importance of its energy demand. Total consumption and electrical consumption are increasing, according to Institute for Diversification and Energy Saving (IDAE) [1], to 17% and 25%

* Corresponding author. Tel.: +34 954557611; fax +34 954557629.
E-mail addresses: mpablorom@us.es (M.P. Pablo-Romero), asb@us.es (A. Sánchez-Braza), mariapv_l@hotmail.com (M. Pérez).
[1] Tel.: +34 954557529; fax: +34 954557629.
[2] Tel.: +34 954557611; fax: +34 954557629.

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http://dx.doi.org/10.1016/j.rser.2013.01.034

at national level, and 25% and 29% at the EU27 level, respectively. At the national level, various factors such as the increase in the number of homes, consumption habits, progressive equipping of the homes and an improvement in the standard of living, mean that an upward future trend can be anticipated regarding this sector's share of the energy demand.

Following IDAE [1], the average consumption of a Spanish home is 10,521 kWth. Some 47% of that consumption corresponds to heating and around 19% for sanitary hot water. Renewable Energies (REs) represent 17.7% of the sector's consumption. Some 94% of the REs come from biomass. The REs represent only 1.9% of heating consumption, with a small solar thermal energy presence of only 0.5%. For hot water, the REs represent 1.7%, with a majority presence of solar energy, at a little over 63%. These figures still show the scarce presence of REs in the sector, and of solar thermal energy in particular.

In terms of capacity of low temperature solar thermal energy installed per inhabitant, at the end of 2010 Spain had a capacity of 35.3 kWth/1000 inhabitants [2], coming 19th in the world ranking, far behind Cyprus (577 kWth/1000 inhabitants), Israel (397 kWth/1000 inhabitants) or Austria (388 kWth/1000 inhabitants). This despite Spain having very high levels of solar radiation, that allow solar systems to cover around 65.3% of the demand for heating and hot water [3].

Some barriers impede citizens installing technologies that use REs in their homes, solar energy in particular. To date only 11.2% of homes have some type of installation with these characteristics [1]. Regarding solar thermal applications, there are two main technical barriers [4]: the calorific losses of the storage systems [5] and some technical difficulties related to the compatibility with some building construction materials. Despite these technical limitations, perhaps the larger barriers are economic, basically related to the initial cost of the system. The detractors of these systems compare the initial costs with those of the conventional technological systems, which have an ample industrial experience and economies of scale, and do not include the negative externalities of an environmental nature in the costs. According to Jacobsson and Johnson [6], solar energy technologies do not internalise the profits that are derived from their use, which is why they are not competitive. In addition, it is necessary to add higher maintenance costs to the initial cost of the systems [7]. The long period of return or amortisation must be added to these economic limitations of the systems. Thus, for example, for water heating systems, this period is about 7 years [8]. Altogether, these costs discourage the installation of solar systems in the residential sphere [9], which does not allow adequate use to be made of the advantages that these technological systems offer.

The use of these systems entails clear environmental benefits. According to Solangi et al. [10], they do not exhaust natural resources and do not generate CO_2 emissions or waste products. Furthermore, they generate other advantages, such as increasing national energy independence and allowing a greater diversification of energy sources, which in turn increases the security of the energy supply [11].

The advantages that these systems present, and the existence of barriers that impede the spread of its use for heating or hot water, have encouraged countries to develop policies to stimulate the development of solar thermal systems. Globally, the measures adopted to date are very diverse. Some works review these measures at the global level, and include those of Timilsina et al. [4], Solangi et al. [10], Sarzynski et al. [12], and Cansino et al. [13]. At the Spanish level, there have also been some reviews made of the measures taken in some specific areas of the country, whether for promoting renewable energy in general or solar energy in particular. Among these studies can be mentioned Prados [14], Gómez-López [15], and Ramos et al. [16].

This work undertakes a complete review of the measures taken to date to promote low temperature solar thermal energy in Spain, and analyses the specific policies developed for that purpose. This analysis of these measures covers the whole of Spain, and allows assessments to be made of their effects in relation to the objectives set for 2010 and their foreseeable effects in relation to the 2020 objectives.

This work is structured as follows. Section 2 analyses the present situation of solar thermal energy in the world and in Spain, and the set objectives. Section 3 covers the legislative regulation related to this energy. Section 4 shows the tax and financial incentives adopted at national, regional and local level. Section 5 discusses the effects of these policies. Finally, the conclusions are presented.

2. Present situation and objectives

2.1. Development of solar heating thermal capacity

By the end of 2010, the solar thermal collector capacity in operation worldwide, equalled 195.8 GWth, corresponding to 279.7 million square metres [2]. The vast majority of this capacity is installed in China (60%), Europe (18%), and the United States (7.5%).

The early development of this technology on a large scale, took place in the 1960s in Australia, Japan and Israel [17], although its strong growth, mainly in China and Europe, has been over the past decade. In Europe, the market size more than tripled between 2002 and 2008 [18]. However, the 2008 economic slowdown resulted in decreases of 10% in 2009 and 13% in 2010, while in 2011 the newly installed capacity remained close to the 2.6 GWth in 2010 [19]. In China, the installed capacity at the end of 2011 was 193.6 million m^2, almost 4.5 times the capacity in 2002; the financial crisis has not affected it, and the use of solar domestic hot-water heaters has continued to grow rapidly, by 16% to the end of 2011 [19].

This success may be explained by its competitiveness compared to alternative technologies and the passing of the Chinese "Renewable Energy Law", which included policy incentives [20]. In future, the 12th five-year plan proposes to increase the country's solar water-heating capacity to 280 GWth by 2015 and 560 GWth by 2020. Apart from domestic hot water, the Chinese government foresees a need to expand SHC deployment to industrial applications in order to realise the 2015 and 2020 targets. China's solar thermal industry will concentrate more on application markets, particularly in the areas of spaceheating and cooling, industrial and agricultural production, expansion from low temperature to mid-high temperature, and testing and certification of applications.

Meanwhile, the evolution of the installed capacity in the U.S. has not been continuous. Solar water-heating has shown only two years of strong growth in the last 10 years. In 2006, solar water-heating installations more than doubled compared with 2005. Then in 2008, installations grew by 56% compared with 2007 [21]. The solar water-heating market has responded to increases in federal incentives.

To stimulate new solar thermal installations, many countries have established several promotional measures. Based on the IEA [22] report, Table 1 shows the summary of G-20 country renewable heat policies in 2011. Eleven countries have targets for renewable heat and four of them have targets specific to solar heating technologies. Seven countries have used capital grants, five have used rebates and one has introduced a specific feed-in-tariff system to the heat sector (United Kingdom).

Table 1
Summary of G-20 country renewable heat policies.
Source: Own elaboration from IEA [22] data.

Country	Targets	Grants	Tax incentives	Feed-in-tariff	Finacial incentives
Argentina		✓			
Brazil	✓				✓
Canada		✓	✓		✓
China	✓				✓
European Union	✓				
France	✓	✓	✓		✓
Germany	✓	✓			✓
India	✓				
Indonesia					
Italy	✓				
Japan		✓			
Mexico	✓	✓			
Republic of Korea	✓				
Saudi Arabia					
South Africa			✓		
Spain	✓	✓	✓		✓
Turkey					
UAE					
United Kingdom	✓			✓	
United States			✓		

In addition to these measures, some countries have a mandatory regulatory framework, as in Germany, or a policy framework, as in France, Japan, Spain, South Africa, Turkey and the United Kingdom.

2.2. Spanish situation and objectives

The present situation of the production and consumption of REs in Spain, and their future objectives, are the outcome of a set of actions that have been undertaken from the year 2000. Initially the Plan for the Promotion of Renewable Energies in Spain 1999–2010 [23] established objectives by areas, with the result that renewable energy sources covered a minimum of 12% of the total primary energy demand in 2010. The purpose of this objective was to follow the recommendations of the White Paper of the European Commission [24]. This objective was later assumed in the 2005–2010 Renewable Energies Plan (REP) [25]. This constituted a review of the former, in which the efforts by areas were distributed in a different manner, to enable the attainment of the said global objective, and the fulfilment of the objectives indicated in the new European Directives that have been incorporated into to national legislation. Thus, for the case of the electricity, the Directive 2001/77/EC established that 29.4% of the gross national consumption of electricity, in 2010, had to be generated from renewable sources. In addition, Directive 203/30/EC set the target of 5.75% for the use of biofuels or other renewable fuels in transport, by the end of 2010. This plan also set the target for REs for thermal use, and established that a production of 4445 Ktoe of primary energy had to be met from renewable sources. From that 4445, 376 Ktoe would be produced by low temperature, solar, thermal energy, which supposed 4,900,805 m^2 installed, starting from a baseline of 51 Ktoe, with 700,433 m^2 in 2004.

Nevertheless, as at 2010, these ambitious targets have not been fulfilled. According to data from the Solar Association of the Thermal Industry (ASIT) [26], a significant annual increase took place until 2008, but from that date the annual increase has been descending and, in the end, the sought objective has not been achieved. Fig. 1 shows that 2,460,000 m^2 and 183 Ktoe were reached in 2010, about half of the objective to be reached. In spite of this, it is possible to say that Spain has had strong, accumulated growth throughout these years. According to the figures offered by IDAE [27], the increase for the whole period was 198%, with an average annual increase of 19%.

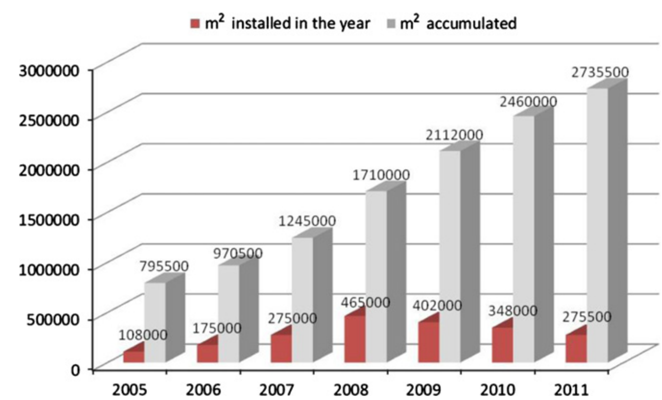


Fig. 1. Installed low temperature solar facilities in Spain.
Source: ASIT [26].

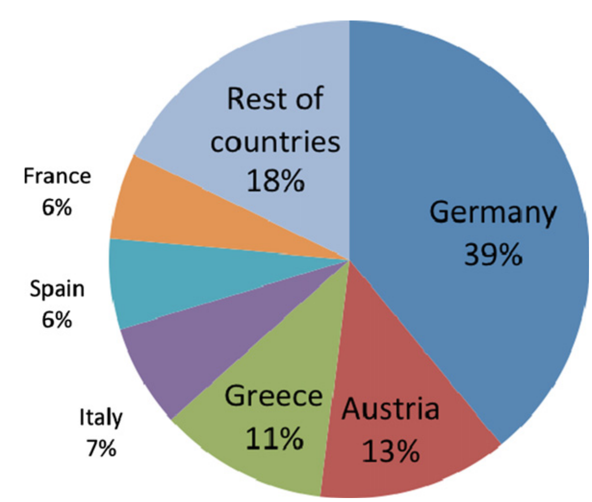


Fig. 2. Solar thermal capacity installed in Spain (2010).
Source: Eurobserver [28].

Fig. 2 shows the solar thermal capacity installed in Spain as 6% of the total capacity installed in the EU27 as at 2010. This places Spain fifth in the EU27, with 1,542,000 MWth, whereas Germany has the greatest installed capacity, with 39% of the total.

Some EU27 countries have decreased the number of new facilities in recent years, whilst others, Italy and France for example, have followed a positive evolution. This shows that Spain has been very sensitive to the economic crisis, and basically to the property crisis.

The downward trend of recent years continues in 2011, according to Fig. 1. This is especially worrying when faced with achieving the new objectives established in the National Renewable Energy Action Plan (NREAP) [29]. The NREAP establishes specific objectives to fulfil those established in Directive 2009/28/EC, relating to the promotion of the use of energy from renewable sources. This Directive sets general targets of a minimum quota of 20% of energy from renewable sources in the gross final energy consumption of the EU27, and a minimum quota of 10% of energy from renewable sources in the energy consumption of the transport sector in each Member State for the year 2020. In Spain, this translates into renewable sources representing at least 20% of the final energy consumption in 2020.

In the area of thermal energy, the target is to use REs for 17.2% the final energy consumption for heating and cooling, which represents a total of 5357 Ktoe. Of this total, 12% is to come from low temperature solar thermal energy, which translates as a target for this type of renewable energy of 644 Ktoe in 2020, which involves a surface area of 10,000,000 m^2.

3. Regulation

One of the instruments that has come to be used in Spain for the promotion of REs is regulation by means of the approval of a series of laws and regulations. The legislation at the national level arises as the result of the incorporation of Directive 2002/91/EC relating to buildings. This legal incorporation has given rise to the Technical Building Code (TBC) (Royal Decree 314/2006), to the basic procedure for energy efficiency certification (Royal Decree 47/2007) and to the Regulation of Thermal Installations in Buildings (Royal Decree 1027/2007).

The TBC is the regulatory framework that establishes the demands indicated in the objectives of the law and its basic requirements in a structured manner. Under the TBC, new and rehabilitated buildings must, among other energy requirements, incorporate solar thermal energy. A minimum energy contribution is established depending on the climatic zone and the sanitary hot water demand. The Regulation of Thermal Installations in Buildings establishes a requirement for the use of available REs in thermal installations, with the objective of covering part of the needs of the building with these energies.

Regarding regional legislation, only Catalonia has established minimum levels of REs and climatic zones in its geographical area, within the construction sector (Decree 21/2006). It establishes the obligation of a minimum use of solar thermal energy for the heating of sanitary water. The other regions have only regulated administrative aspects.

Finally, some Councils have promoted Bylaws for the incorporation of solar installations in all types of buildings of new construction or in the process of rehabilitation, whether houses, offices, sport facilities or hospitals. With these Bylaws, the Councils can regulate the obligation to install solar panels, whose obligatory nature must be greater than that established in the TBC. Barcelona was the first European city to approve a regulation of this type: the Solar Thermal Ordinance, in effect from August 2000. After this, many Spanish Councils approved applicable bylaws in their areas. There are currently more than 50 municipal bylaws that cover around 20% of the population. Madrid and Catalonia are the two Autonomous Communities (ACs) that have the most approved Bylaws. The advantage of these regulations is that they adapt to the specific circumstances of the locality.

4. Incentives

4.1. State incentives

In Spain, three types of incentives exist to promote solar thermal energy: Tax incentives, which act indirectly; non-refundable grants; and finally, favourable lines of finance.

4.1.1. Tax incentives

In the national sphere there are two different types of tax allowances. In the first place, from May 2011, there is up to a 20% reduction allowance in personal income tax (Royal Decree-Law 5/2011) for amounts paid for works made in the home (whether or not the habitual residence), to replace electricity, water, gas or other supply installations with those that use REs. Specifically, the Royal Decree-Law mentions the installation of solar panels, to contribute to the production of the sanitary hot water demanded by homes. The maximum allowance per tax period is 1350€. When the amount is greater than that allowance, the deduction can be applied in successive tax periods, up to a total of 4000€. Prior to the application of this Decree Law, there was the possibility of an allowance of up to 10% of the tax bill, although in this case it was only applicable to the habitual residence.

Nevertheless, successive reforms of Corporation Tax have generated some uncertainty about the amount to be deducted from the tax bill. The reform of this tax by Law 35/2006, established a progressive elimination of the environmental allowances, and specifically of the allowances for investment in solar installation, so that this allowance disappeared in the 2011 financial year. However, Law 2/2011 on sustainable energy reactivated the allowance for environmental investments, establishing a deduction of 8%, which was greater than the 4% of 2009, and the 2% of 2010. So, finally, for investments in installations destined for environmental protection, the deduction for companies whose financial year coincides with the natural year, is 2% for investments made in 2010 and 2011, and 8% for investments made in 2012.

4.1.2. Direct grants

The national government awards direct grants through IDAE to those solar thermal energy installations which are not obligatory under the TBC. These grants are channelled through the regional administrations and are enshrined within the 2005–2010 REP [25], in the 2008–2012 Action Plan of the Energy Saving and Efficiency Strategy in Spain (APESES) [30] and the 2011–2020 REP [31]. These grants are distributed jointly with whichever entity each Autonomous Community (AC) designates to promote the use of REs.

The users of solar thermal energy installations can benefit from up to 37% of the eligible standard cost. This cost varies based on the type of installation, in accordance with Table 2. It is a necessary condition that the execution of the installations is carried out by an IDAE accredited company, which guarantees them and their maintenance.

Table 2
Standard cost of solar thermal installations.
Source: IDAE [27].

Prefabricated systems	1160€/Kw (812€/m^2)	
Systems by elements	Up to 14 Kw (20 m^2)	1160€/Kw (812€/m^2)
	More than 14 Kw (20 m^2)	1015€/Kw (710.5€/m^2)
	Special applications	1450€/Kw (1015€/m^2)
Innovative projects	Up to 50% more than the standard costs	

4.1.3. Favourable financing

Financing for diverse investment projects related to REs, and solar thermal energy in particular can be obtained through IDAE.

Through the Solcasa programme, accredited energy service companies can be eligible for loans of a maximum of 10 years, and up to 250,000€ at an interest rate equivalent to Euribor +2.2%. The objective of the loan is to boost solar thermal energy installations in non-industrial buildings. The authorised companies offer their clients an integrated service of energy sales undertaking the design, installation, and maintenance of the installation. Initially, the user does not pay anything until the installation comes into service, at which time, and for a maximum term of 10 years, the authorised company invoices for the thermal energy contributed by the installation and actually consumed, and an amount for the amortisation of the installation. Therefore, the acquisition for the end user is advantageous, through not having to face the immediate cost of the investment, which is paid for over the ten years of the contract. This loan is compatible with the grants managed by the regional administrations, which have to be allocated to the amortisation of IDAE loan, thereby reducing the term of amortisation of the loan. If the projects are outside the established limits, then these companies can benefit from the Large Thermal Installations Programme, in which case, the maximum limit of project finance will be 80% of the investment, and 3 M€ per project and 5 M€ per company.

Alternatively, all the companies can benefit from the Third-Party Finance programme. In this case, IDAE directly makes the investment in a strategic project, for energy saving or generation with renewable sources, proposed by a company. IDAE recovers the investment by means of the energy saving induced or the energy produced. Once the investment is recovered, the installation belongs to the proprietor.

Finally, individuals, SMEs, groups of property owners, Councils and other legal entities, with the exception of large companies, can ask for an 11 year loan at an interest rate of Euribor+0.30% with one year's grace for payment for solar thermal energy projects. IDAE undertakes this financing through five financial organisations.

4.2. Incentives from the Acs

Basically the ACs have developed two types of incentives: tax allowance and non-refundable grants.

4.2.1. Tax allowances

Apart from the state allowances from which all tax payers may benefit, the ACs can establish additional personal income tax allowances for the tax paying residents in their areas. Table 3 shows the specific allowances of the ACs that have specific allowances relating to the promotion of solar thermal energy.

Furthermore, according to the Foral Tax Code of the Basque Country [33], there is a deduction of the corporation tax liability of 30% of the investments in equipment included in the Basque Listing of Clean Technologies [34], among which are included the evacuated tube and flat plate solar thermal panels for water heating.

4.2.2. Grants

The structure of recent development has been bound to the public support of investment, via grant, with shared management of public funds from the General State Administration, by IDAE, and the ACs, which have been channelled through the signing of agreements between the ACs and IDAE, to carry out the high-priority measures identified in REP 2005–2010 [25].

In this way, the General State Administration transfers the funds, through IDAE, to the ACs in accordance with certain objective technical criteria applicable to each region and to each of the sectors to which the measures are directed. Thus, in addition to coordinating the anticipated measures throughout the whole country, the needs and objectives of each of the ACs are also taken into account by acknowledging their own peculiarities and competences.

Between 2006 and 2010, Collaboration Agreements were signed with each of the ACs. These agreements defined and established the conditions under which the public support procedures contemplated in REP 2005–2010 [25] would be put into practice in the specific territorial sphere of each AC, with the funds transferred by IDAE. Therefore, these agreements contain the financial investments for each and every measure to be undertaken; some common to all the regions (priority measures), and others specific, adapted to the energy reality of the respective regions. Some of these agreements also include measures related to the 2008–2012 APESES [30].

At the expiry of the term of the REP 2005–2010, many ACs considered it opportune to sign Transition Agreements with IDAE, to avoid interruption in the aid while the new REP 2011–2020 was approved [31]. With this aim, the General State Administration authorised a budget (via IDAE) for the signing of Transition Agreements in 2011 with the different ACs to support the REs.

The REP 2011–2020 [31] was approved, and throughout 2012 new agreements were signed for the definition and putting into practice of the public support procedures contemplated in this REP. In addition, some of these agreements incorporate measures related to the 2008–2012 APESES [30].

The extent to which these subsidised procedures contribute to a reduction of atmospheric CO_2 emissions must also be considered, as it is possible to co-finance the subsidies with FEDER funds if the reduction of emissions is one of the objectives of these subsidies.

Table 4 summarises the specific benefits included in the latest agreements signed, to date, between IDAE and the Acs.

Also, in accordance with Regulation (EC) 800/2008, it must be taken into account that when the beneficiary is a company, the amount of subsidy taken together with other aid that can be received for these activities, will in no case exceed the maximum limits indicated in Table 5, and which will be calculated on the eligible cost.

Table 3
Personal income tax allowances in the ACs for solar thermal energy investments in homes.
Source: Tax Authorities [32].

Autonomous Community	Personal income tax allowance for the investment (%)	Limits of application
The Canary Islands	10	10% of the complete autonomous tax bill
Castile and Leon	10	Maximum baseline of this allowance: 10,000€ annually
Extremadura	10	Maximum baseline of this allowance: 4000€ annually Maximum tax base: 53,007.20€
Murcia	10	Maximum baseline of this allowance: 10,000€ annually
Valencia	5	Maximum baseline of this allowance: 4100€ annually

Table 4
Regional aid for solar thermal energy investments in homes.
Source: Own elaboration.

Autonomous Community	Standard cost	Maximum aid on the standard cost
Andalusia	There is a list of investment items eligible for incentives, including: investments in buildings, public works and necessary installations, investments for auxiliary installations, machinery, installations and capital equipment, computer or control equipment directly related to the energy project, as well as other investments that are considered necessary for the project.	The projects are included in some of the following categories (in turn divided into subcategories): energy saving and efficiency, RE installations, energy utilisation installations and energy studies and dissemination activities, and energy infrastructure improvements. The maximum amounts range, in general terms, between 40% and 70% of the standard cost, based on the category of the project and whether it is made by large, medium or small companies or by another entity that is not a company. In addition, these amounts can be increased by 5% or 10% based on the subcategory (within each category) in which the project is included.
Aragon	In accordance with the general directives shown in Table 2.	Up to 37%, with the limit augmentable to 50% for the case of systems for telemonitoring and visualisation of the produced energy.
Asturias	In accordance with the general directives shown in Table 2.	Up to 37%, with the limit augmentable to 50% for the case of systems for telemonitoring and visualisation of the produced energy.
Balearics	In accordance with the general directives shown in Table 2.	For applications in general, maximum amount is 300€/m^2 up to 20 m^2, and 260€/m^2 above 20 m^2, with a general maximum limit of 37% of the cost of the installation, augmentable to 50% for the case of telemonitoring and visualisation systems. The maximum subsidy per project will not exceed 200,000€.
The Canary Islands	In accordance with the general directives shown in Table 2.	The maximum subsidy per action will not exceed 37% of the standard cost, with the limit augmentable to 50% for the case of systems for the telemonitoring and visualisation of the produced energy. Maximum amounts of 120,000€ per subsidy and 240,000€ per beneficiary are applied.
Cantabria	In accordance with the general directives shown in Table 2.	Up to 37%, with a maximum of 45,000€ for a single installation, and 45,000€ for the same beneficiary.
Castile-La Mancha	In accordance with the general directives shown in Table 2, for the categories of prefabricated systems and systems by elements.	Up to 30% of the eligible cost, with a maximum of 30,000€ per project, and without the same beneficiary there could be more than one subsidy in the same call and within the same technological area.
Castile and Leon	Several types of facilities are distinguished, oscillating the cost of reference between 190€/m^2 and 2700€/m^2 based on the type of installation.	The maximum aid ranges between 15% and 45% of the standard cost, based on the type of installation and whether or not the beneficiary is a company, with a 60,000€ limit, irrespective of the type of beneficiary.
Catalonia	In accordance with the general directives shown in Table 2.	Up to 37%. In the case of innovative projects, a rate of 55.5% will be applied on the maximum eligible cost.
Valencian Community	In accordance with the general directives shown in Table 2.	Generally, the established aids include up to 45% of the eligible cost of the project. However, it may be increased by 10% for medium sized companies, and by 20% for small companies, individuals, Councils, public organisations and not-for-profit organisations and institutions.
Extremadura	The eligible costs for each type of installation are not specified.	The allocation of aid is based on the type of beneficiary and the number of requests presented, and according to the score obtained according to a series of established assessment criteria. In any case, there is a maximum limit of 40,000€ per project.
Galicia	Eligible investment is considered to be the cost of the equipment and components that comprise the installation (solar thermal panels, heat collectors, valves and connections, insulation etc.), as well as its assembly and connection, any associated public works, the installation engineering design, direction of the work and commissioning.	The maximum amount of the subsidy will be 35% of the eligible investment, except for municipal installations where this percentage may be increased to 45%. In any case, the maximum aid per project is 60,000€.
Madrid	Eligible costs will be considered to be those corresponding to the equipment of the installation as well as its assembly and connection, associated public works, installation engineering design, direction of the work, commissioning, technical documentation, user manuals and permissions and aid procedures.	The amount of aid for cooling applications, other special applications and innovative projects is 375€/m^2 of usable capture. For the rest of the applications, the amount is 260€/m^2 of usable capture.
Murcia	In accordance with the general directives shown in Table 2.	Up to 37%, with the limit augmentable to 50% for the case of systems for the telemonitoring and visualisation of the produced energy.
Navarre	The eligible costs for each type of installation are not specified. In general terms, eligible cost is considered that derived from investments in elements exclusively needed to reach the energy production objectives.	Subsidy limit of 30% for projects without architectural integration, 40% for projects with architectural integration, and 50% for audits of existing facilities. In this case, maximum subsidies of 1000€ and 5000€ are established based on whether they are in audits of installations smaller or larger than 20 m^2 respectively. However, without prejudice to the above, the Efficiency and Renewable Energies Section reserves the right to apply other maximum eligible costs when the installations for which subsidy is requested have higher than market costs.
Basque Country	In accordance with the general directives shown in Table 2.	Maximum aid of 35% of the standard cost. In the case of accumulation of other institutional aid, the maximum total subsidy will be 40% of the eligible cost. The amount of aid may reach a maximum of 100,000€ for the same beneficiary in one or several installations.
La Rioja	In accordance with the general directives shown in Table 2.	Maximum aid of 37% of the standard cost.

Table 5
Aid limit for companies.
Source: Regulation (EC) 800/2008.

Small companies	65%
Medium companies	55%
Large companies	45%

In summary, it is possible to emphasise the legislative complexity and difficulty derived from this disparity of agreements signed between IDAE and each of the ACs. This diversity of agreements for each Community, although having the advantage of allowing the aid to be adjusted to the regional specifics, it has the great disadvantage of presenting a very complicated and confused aid structure which supposedly makes it difficult to use them.

It must also be taken into account that the periods for requesting aid are also very different from one AC to another, both regarding the time of year in which the aid is announced, and the length of time to apply for it. Thus, some ACs open calls with long time periods (months or even years, in the exceptional case of Andalusia), whilst others have very limited time periods (a few weeks). In addition, each of the ACs announces its aid at the time of year it considers opportune, whereby, based on the time of year, there can be open calls in some ACs but not in others. All this can cause a great degree of ignorance and uncertainty in those considering undertaking installation of solar energy systems, since they may not be clear on when they can request aid or even if the call is open.

4.3. Local incentives

There are two types of aid at the local level for the installation of solar thermal energy systems: subsidies and certain tax advantages. These subsidies and advantages are established to promote the solar thermal installations which are not obligatory, in accordance with the current regulation.

4.3.1. Subsidies

The Councils have power to grant non-refundable subsidies similar to those granted by the ACs. The subsidies will not exceed, in any case, 50% of the cost of the activity to which they are applied. Each council is empowered to announce subsidies for the implementation of solar energy.

The usual procedure for granting subsidies has a competitive basis, which compares applications and establishes a priority among them, in accordance with the assessment criteria previously set out in the rules and regulations, and in the call, such that subsidies go to those adjudged to have obtained the highest rating. Another way of granting subsidies is in a direct manner, by nomination in the budget of the local organisation, although this method demands such planning that this formula of granting subsidies is little used.

4.3.2. Tax advantages

Councils have power to establish tax advantages on some local taxes through tax ordinances, within the limits established by Royal Legislative Decree 2/2004.

Table 6 shows that, in accordance with Article 103 of Royal Legislative Decree 2/2004, the Councils can establish an advantage of up to 95% in the tax on construction, installation and works (ICIO) in favour of those buildings, installation or works which incorporate solar energy systems for the production of heating or electricity. The potential beneficiaries include all type of buildings, in addition to the domestic sector, such as hotels, hospitals, sports complexes, schools, commercial centres in the service or industrial sectors. In relation to this tax, the Councils can also establish a reduction of up to 50% of the tax bill when the installations are linked to infrastructure promotion plans. This reduction is applied after having taken the previous one into account.

Table 6
Maximum reductions foreseen by law.
Source: Own elaboration.

Tax	Maximum rate (%)
Tax on construction, installation and works (ICIO)	95
Tax on economic activities (IAE)	50
Real estate tax (IBI)	50

Secondly, in accordance with RLD 2/2004, the Councils can establish a reduction of up to 50% of the real estate tax (IBI) for properties in which solar thermal systems have been installed. The application of this reduction is conditional on the installation including collectors which have the corresponding approval of the competent authority.

Finally, the Councils can also establish reductions of up to 50% in the tax on economic activities (IAE), which taxes the undertaking of certain economic activities, for those parties liable to pay the municipal tax bill and which use or produce energy from installations using REs or from co-generation systems. In order to apply this reduction, the installations using REs and co-generation systems are considered to be those included and defined in the REP 2005–2010 [25], among which are the installations for the use of solar thermal energy.

Table 7 shows the reductions established in the Spanish Provincial capitals. It clearly reflects the large differences between the Councils. Also, the last column shows the Provinces that have specific ordinances relating to low temperature solar thermal energy.

5. Discussion

Over recent years, the growth in the use of REs has been remarkable in Spain, the EU27 and the world in general. This increase has also been observed in the use of solar energy. Spain, with a high solar intensity index, is at the forefront of the countries that use this energy adequately. It is the leading European country and second placed globally, in terms of solar thermoelectric energy, and the second placed country in Europe and in the world, in terms of photovoltaic energy [35]. However, its position falls to position 19 when considering low temperature solar thermal energy installations per number of inhabitants. In Table 8, columns 2 and 3, give the data on these installations per AC in Spain, and column 4 gives the solar intensity of each region. In general it can be seen that most of Spain has high levels of solar radiation, although the installations per capita are not high. All the ACs are far from the levels achieved by those countries with greater development in this technology. However, in general, the ACs with a greater intensity, are also those that have the greater number of installations per capita, although there are important exceptions. Such is the case of Navarre, with a relatively low solar intensity level and a high number of installations. Perhaps that can be explained by the wide development of RE industries in that Community. The contrary case can be exemplified by Extremadura, with ample solar intensity, but with few installations.

The existence of technical, economic and even institutional barriers, has restrained the development of the use of this energy [36]. This has prevented the achievement of the objectives contained in REP 2005–2010 [25], with only half of the preselected targets having been reached. In this sense, the measures established to promote solar thermal installations have been

Table 7
Local reductions established to promote low temperature solar. Thermal energy by the province capitals and ordinances approved for regulation.
Source: Own elaboration.

Autonomous Community	Province	Real estate tax (IBI)	Tax on construction, installation and works (ICIO)	Tax on economic activities (IAE)	Ordinances
Andalusia	Seville	50l	95%	50%	✓
	Malaga	15%	95%	10%	✓
	Granada	50%	95%	20%	✓
	Almeria	0%	0%	10%	–
	Cordova	30%	95%	50%	–
	Cadiz	–	–	50%	–
	Jaen	50%	0%	20%	✓
	Huelva	–	25%	0%	–
	Huesca	50%	55%	50%	–
Aragon	Teruel	–	50%	50%	–
	Saragossa	50%	50%	30%	✓
Asturias	Oviedo	–	–	–	✓
Balearics	Palma de Mallorca	50%	95%	–	–
The Canary Islands	Palmas Gran Canaria	–	75%	–	✓
	Sta. Cruz de Tenerife	25%	95%	–	–
Cantabria	Santander	50%	95%	–	✓
	Cuenca	30%	30%	30%	–
	Albacete	–	50%	–	–
Castile-La Mancha	Ciudad Real	–	90%	50%	–
	Guadalajara	30%	–	50%	–
	Toledo	–	–	–	–
	Burgos	–	95%	9%	✓
	Zamora	–	–	–	–
	Avila	50%	50%	30%	–
	Segovia	–	95%	–	–
Castile and Leon	Soria	50%	50%	50%	✓
	Salamanca	50%	95%	50%	–
	Valladolid	–	95%	10%	✓
	Leon				
	Palencia				
	Lerida		95%	–	✓
Catalonia	Tarragona	–	95%	–	–
	Barcelona	50%	–	50%	✓
	Gerona	50%	–	–	–
	Valencia	–	95%	–	✓
Valencian Community	Alicante	–	–	–	–
	Castellon	–	95%	–	–
Extremadura	Badajoz	–	–	–	–
	Caceres	–	–	–	–
	Corunna	–	90%	50%	–
Galicia	Orense	–	30%	–	–
	Lugo	–	50%	–	–
	Pontevedra	–	50%	–	–
Madrid	Madrid	40%	95%	–	✓
Murcia	Murcia	–	50%	10%	–
Navarre	Pamplona	–	–	–	✓
	Vitoria	50%	30%	30%	–
Basque Country	Bilbao	50%	10%	50%	–
	San Sebastian	–	95%	–	✓
La Rioja	Logroño	–	30%	–	–

insufficient to boost these solar facilities. Clearly, faced with the future, thought must be given to the need to introduce new types of aid and promotion [4].

In Spain, these measures have been adopted at three different levels of authority. At national level a regulatory framework has been developed, especially in the TBC. Subsidies have been granted through IDAE and managed by the ACs. Deductions in Income and Corporation Tax have been established. Some financial instruments have also been established.

Spain was the first country to establish a regulatory framework which obliges the installation of solar thermal energy systems in new and rehabilitated buildings, through the TBC. This regulation has had a very important impact, since most of the installations that have been carried out are directly linked to the TBC. Thus, according to ASIT [26], the percentage of new installations linked to the TBC was 83% in 2010. This percentage has been rising over the years, and is in agreement with the percentage by which new installations associated to aid from IDAE has been decreasing. So, really, the establishment of the regulatory framework has been fundamental. However, this framework is not sufficient to reach the established objectives. It can be said that the TBC only affects new or rehabilitated buildings, which constitute a small proportion of the total, and which is why its effect is limited. Even more so when the construction sector in Spain is experiencing an extremely complicated time, with a deep crisis.

The second of the instruments used is the concession of subsidies that are granted through IDAE. However, these subsidies have very little centralisation, because they are managed through the ACs in a manner that varies from one to the other, by virtue of agreements signed by each Community and IDAE. There is no common pattern between these agreements which is why there are many differences between the ACs. Although these

Table 8
Indicators of incentives for the promotion of solar thermal energy installations in Spain.
Source: Own elaboration.

Autonomous Community	m^2 installed for each 100 people, 2006	Increase in m^2 installed for each 100 people (2006–10)	KWh per m^2	Increase of buildings for each 100 inhabitants (2007–2010)	Subsidy per inhabitant granted by the IDAE (€) (2006–2010)	Additional autonomous subsidies	Autonomous tax incentives	Proportion of Councils with local incentives (%age of population covered)
Balearics	7.923	0.99	1520	0.67	4.42			9.09 (46.83)
The Canary Islands	5.260	2.41	1860	0.49	4.23		✓	12.35 (24.76)
Andalusia	3.547	3.20	1669	0.73	1.78	✓		7.42 (32.49)
Navarre	2.869	2.11	1280	0.69	3.45	✓		Not determined
Castile and Leon	2.738	1.07	1476	1.75	2.31		✓	0.49 (11.46)
Catalonia	1.823	0.74	1463	0.46	1.39			13.30 (59.53)
Murcia	1.730	0.25	1800	0.89	1.95		✓	3.53 (14.29)
Asturias	1.643	0.44	1100	0.64	1.04			1.26 (1.01)
Valencian Community	1.604	0.59	1600	0.50	1.44	✓	✓	5.15 (11.21)
Madrid	0.882	0.89	1560	0.29	1.07			14.44 (67.77)
Aragon	0.656	0.33	1490	0.56	1.69			0.54 (51.61)
Galicia	0.636	0.94	1243	0.60	0.74			2.24 (5.84)
Basque Country	0.565	0.65	1130	0.22	0.77		✓	Not determined
Castile La Mancha	0.481	0.68	1570	1.28	2.39			2.04 (9.89)
Cantabria	0.429	0.26	1150	0.76	0.96			8.73 (57.79)
Extremadura	0.351	0.20	1640	1.34	2.00		✓	0.26 (3.27)
La Rioja	0.077	0.24	1420	0.66	1.92			0.57 (0.11)

differences can regulate the subsidies based on the specific characteristics of each AC [13], they also introduce an important segmentation of the market and an excessively broad and complex policy development that may be restraining the development of these systems in Spain. The sixth column of Table 8 shows the large difference that exists in the final amount of aid granted by IDAE per inhabitant, according to AC. In general, it can be seen that the ACs that have better managed the aid from IDAE, and have granted more subsidy per inhabitant, are also those which have more square metres of solar thermal energy systems installed per person (shown in columns 2 and 3 of Table 8). This is in tune with the results of Sarzynski et al. [12] for the U.S.A., which emphasises the importance of the concession of subsidies for the establishment of the new technological systems, by diminishing their costs. It is perhaps for that reason that, currently, subsidies are the main global instrument for promoting this energy [4].

However, the budgetary constraints in Spain and its ACs, mean that this aid is tending to diminish. There is even some uncertainty as to whether the ACs are going to continue promoting these technologies, the way in which they are going to do it and the term in which aid can be requested. Diminishing aid in Spain is in line with the reduction of the aid in other European countries. Subsidies for renewable heat have been lowered in Germany, and the Lower Austrian region and the Czech Republic have stopped all incentives for solar heat. Also, Portugal's market has been hit by the nation's financial crisis [19]. However, not all European countries have reduced their aid. Poland maintains a strong support framework and there are positive signs for renewable heating and cooling in Bulgaria and Romania. Also, other economies are supporting this sector. In China, apart from domestic hot water, the development in the industry sector is encouraging [20]. In Brazil, the government programme "My Home My Life" was implemented at the end of 2009 and there are many regional initiatives from medium to large sized cities by regulating discounts in municipal taxes and making this technology a mandatory requirement for new public and private buildings [37].

The budgetary constraints that diminish the use of subsidies in Spain are in tune with the recommendations of the report of the World Energy Council [38], which considers it desirable that there is progressive reduction in the use of subsidies, and that alternative ways are used to reduce the cost of these types of solar installations.

In this sense, the use of tax incentives appears to have less capacity to stimulate these solar installations than the subsidies. Sarzynski et al. [12] show that those States in the U.S.A. that have established income tax incentives, do not have a greater development of solar technologies. In the case of Spain, the legislative changes, mainly in the case of corporation tax, and the confusion generated about the percentage deduction in certain years, may also have reduced the effect of this incentive. Furthermore, according to Table 8, column 8, it does not seem that there is a relationship, at least causal, between those ACs that have some type of tax incentive and the number of square metres installed per person.

Several reasons may be behind this circumstance. Firstly, there is the fact that tax deductions involve the need to make a previous investment, for which there may not be sufficient liquidity. This is why it may be essential that these deductions are accompanied by good systems of financing or sufficient financial aid. In this sense, State financial support is considered necessary to bear the cost of investment in these technologies [13] especially considering the present financial problems of Spanish banks. Secondly, tax deductions are not sufficiently attractive because they are quantitatively meagre, that is to say, they are not sufficiently significant [12]. In this sense, the present budgetary restrictions may prevent these incentives becoming sufficient. Finally, for tax incentives to have effect, they must remain in operation over sufficient time.

However, tax incentives have the advantage of being easily applicable, without complicated bureaucratic processes, and individuals can easily produce their calculations and their procedures. This may have favourably influenced the existence of local tax incentives, generally those relating to property taxes. In this sense, there does appear to have been a certain relationship between those ACs that have greater population coverage with these deductions, as opposed to those that do not (Table 8, column 9).

It also shows the importance of local policy in the development of REs; in keeping with the European Directive on Renewable Energy [39].

The need to continue supporting this sector in Spain seems to be obvious for progress towards reaching the 2020 targets, since, according to ESTIF [19], the effects of the "stop-and-go" policy measures include significant market contraction, with attendant business closures and job losses. However, continuity in supporting such measures seems difficult in the current context of budget cuts.

Nevertheless, Krozer [40] assesses that the REs led to Europe saving more money than they receive as public support. Thus, the net benefit throughout the oil price cycle 1998–2008, assessed that the electricity consumption of households and services, attributable to the growing use of REs, approached 47 billion euros, which is on average 8 billion euros a year. This net benefit is larger than the total public support for renewable energy, and assumes that the cost of encouraging REs, supported by public funds during low oil prices, is outweighed by the benefits during high oil prices. Therefore, an anti-cyclic EU27 policy is recommended. Following Krozer [40], this net benefit would be larger had the EU27 anticipated high oil prices through more public support during low oil prices, as this would create productive capacity.

In any case, the EU27 member countries may have different interests and do not react quickly, encouraging the REs when no longer needed. Also, in other cases, such as that currently in Spain, the poor economic situation limits the ability to react. Thus, the EU27 should be responsible, with grants and support facilities, for coordination and counteracting imbalances between different countries in order to apply these incentives when they are needed [40].

6. Conclusions

The fulfilment of the objectives established in the NREAP 2011–2020, relating to the use of solar energy for heating use in Spain, makes it necessary to establish a set of incentives that allow the adequate promotion of this renewable energy. To date, the set of incentives established has been insufficient to achieve the goals set out in the REP 2005–2010, with only half of the established targets having been reached. The result is that, currently, Spain occupies 19th position in the world ranking relating to the number of low temperature solar installations per capita, whilst it is the global leader in other types of solar installations.

The measures adopted in Spain in recent years have been varied and have developed simultaneously in various regions. Although in some cases this has allowed the development of measures adapted to the specific characteristics of region, it has introduced large regional differences and a complex and highly diversified regulatory development, which may have raised significant administrative barriers to the development of this technology. This suggests the need to give to a certain harmony and uniformity to the whole current aid system, in such a way that allows the development of a more powerful internal market.

In the regulatory sphere, the establishment of the TBC has meant a great advance for the diffusion of solar installations in buildings. This has also been reinforced by the existence of local Ordinances in much of Spain. However, the capacity of these regulations is limited, given that the number of new buildings out of the total is limited, and the crisis in the construction sector considerably reduces the possibility of advancing by this route. In recent years, these circumstances have led to an evident reduction in the annual increase of new installations in Spain.

The second of the instruments used has been the concession of subsidies. These have been granted by IDAE, although they have been managed through the ACs in a different manner in each of them. This has generated a large difference between the ACs and has caused a highly complex and differentiated regulatory development. In addition, these subsidies have been diminishing over time, due to the need to adjust to ever more restrictive budgets. This is reflected in the scarce positive impact that this aid has had on the total number of new installations in Spain and its trend is downward. In terms of the future, there is great uncertainty about the possibility of maintaining these subsidies, which damages the development of the market.

Neither do tax incentives seem to have had sufficient impact. The regulatory changes at national level have introduced certain confusion into the system, and the regional deductions do not seem to be quantitatively sufficient to stimulate these highly expensive technologies. However, tax deductions can be suitable measures if they are sufficient and accompanied by good systems of financing. In this sense, the financing programmes must be maintained and become more visible, so as to produce a greater willingness on the part of the users to undertake these solar installations.

In this sense, the establishment of local measures is considered adequate, such as the property tax exemptions, which are highly visible, and involve significant cost reductions. Even so, the financial difficulties of the Councils may endanger the existing exemptions and their application by new Councils.

The insufficiency of the measures applied to date, necessitates the study of alternative methods of stimulus. Among them, systems of support for the kWh generated by solar thermal, over a limited time, which would simultaneously stimulate greater efficiency of the installations. In such ways private initiative can be promoted and its dependency of public aid reduced, while establishing suitable mechanisms that do not lead to an increase of the tariff deficit, from which Spain is currently suffering.

In this sense, a profound knowledge and numerical assessment of the environmental advantages and the energy strategy of using solar energy for heating and hot water, can help suitable measures to be taken, by allowing the costs and benefits of solar thermal energy for Society as a whole to be suitably compared.

Acknowledgements

The authors acknowledge the financial support received by the Cátedra de la Economía de la Energía y del Medio Ambiente (Chair of Energy and Environmental Economics) of the Fundació Roger Torné.

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